Part Processing

Mesh Classification

Tim Fuger

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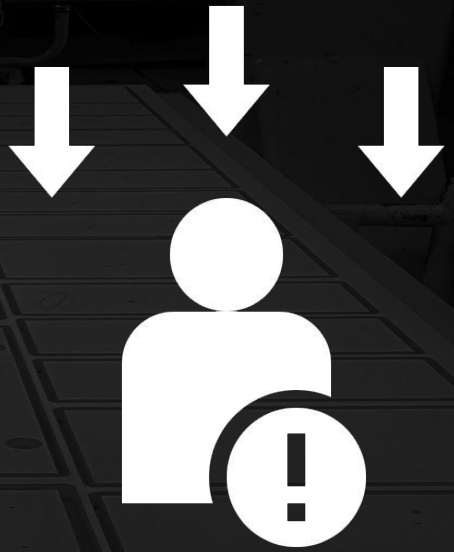
Business Problem

Reduce engineering time and error in order to assign the manufacturing process for individual parts at Fab Inc.

Business Problem

Reduce time

8 hours per month



Reduce human error

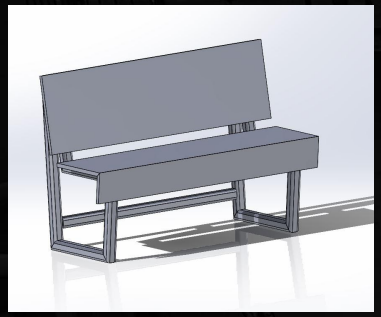
7%

Business Problem

Project objective

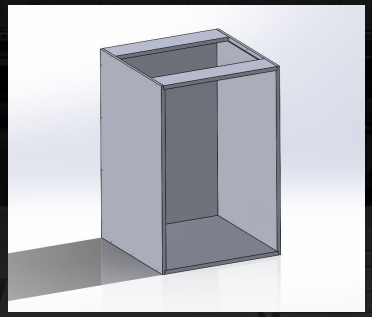
To develop a **Convolutional Neural Network** that can properly identify the required processes for each 3D modeled part.

Data

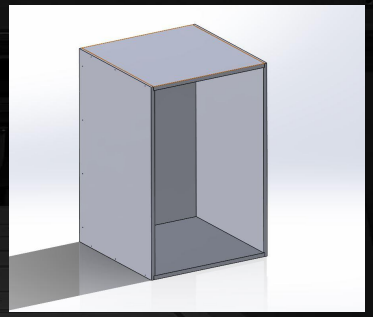


Bench1
4 parts
16 configurations

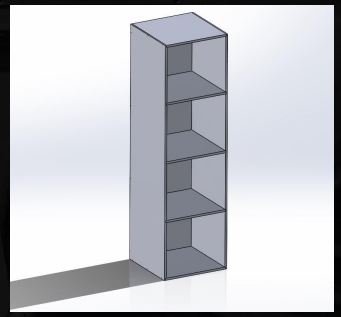
Bench2
3 parts
21 configurations



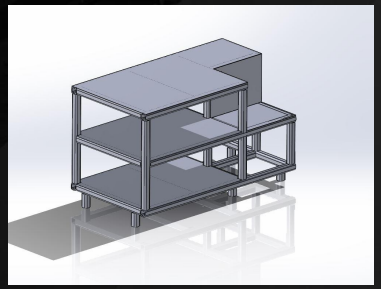
Cab1
6 parts
8 configurations



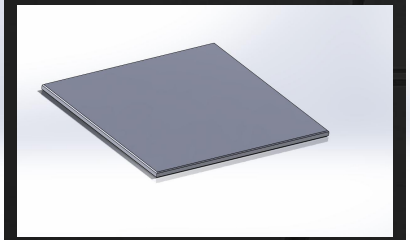
Cab2
5 parts
32 configurations



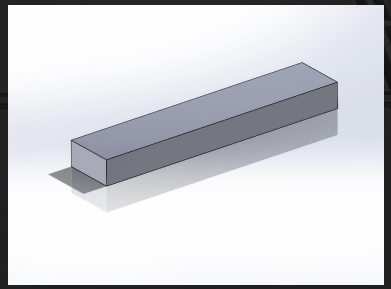
Cab3
6 parts
28 configurations



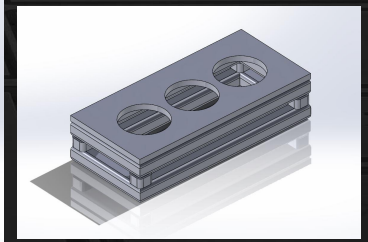
Counter1
5 parts
15 configurations



Shelf1
1 part
96 configurations



Shelf2
6 parts
14 configurations



Station1
2 parts
18 configurations

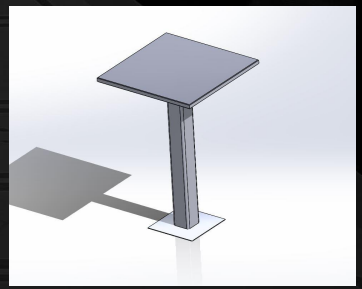
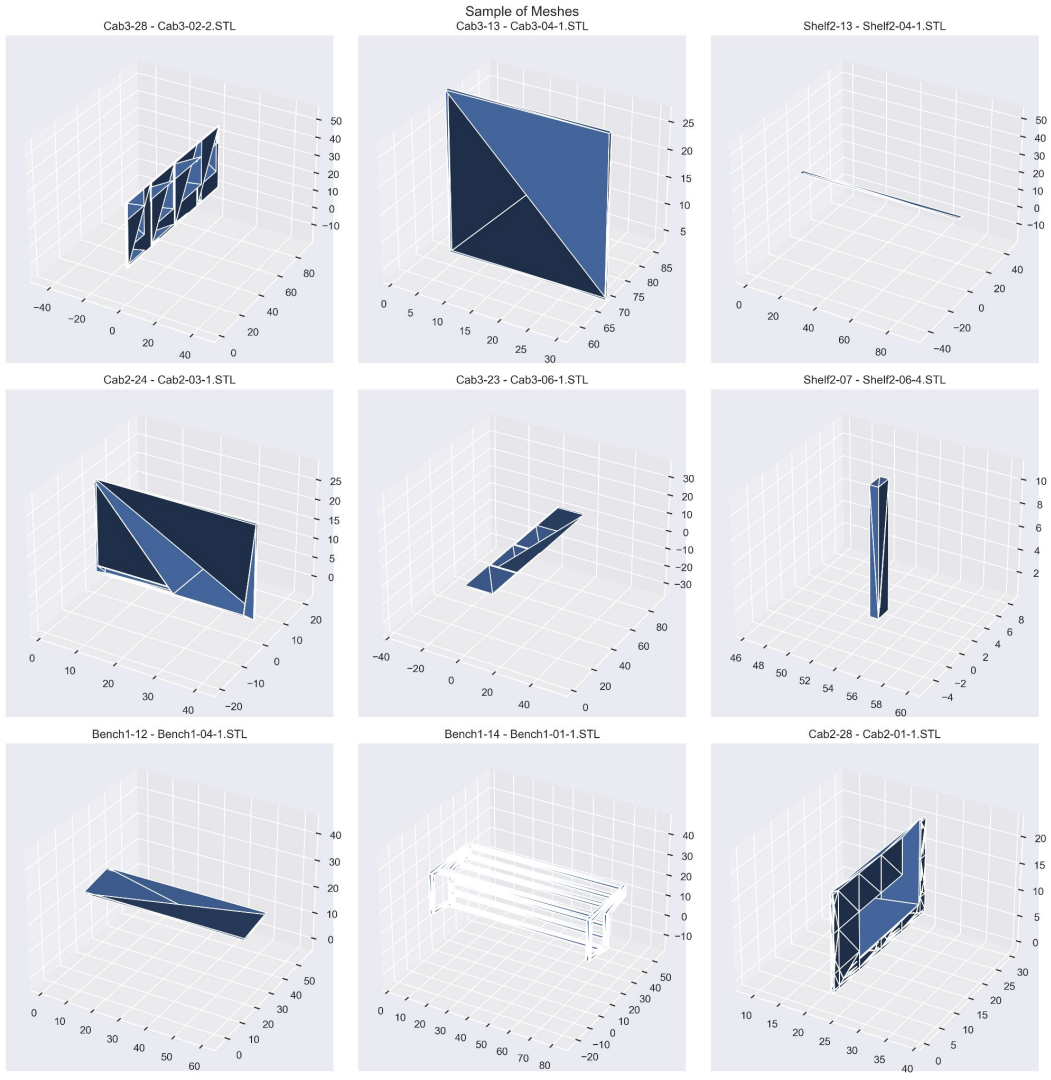


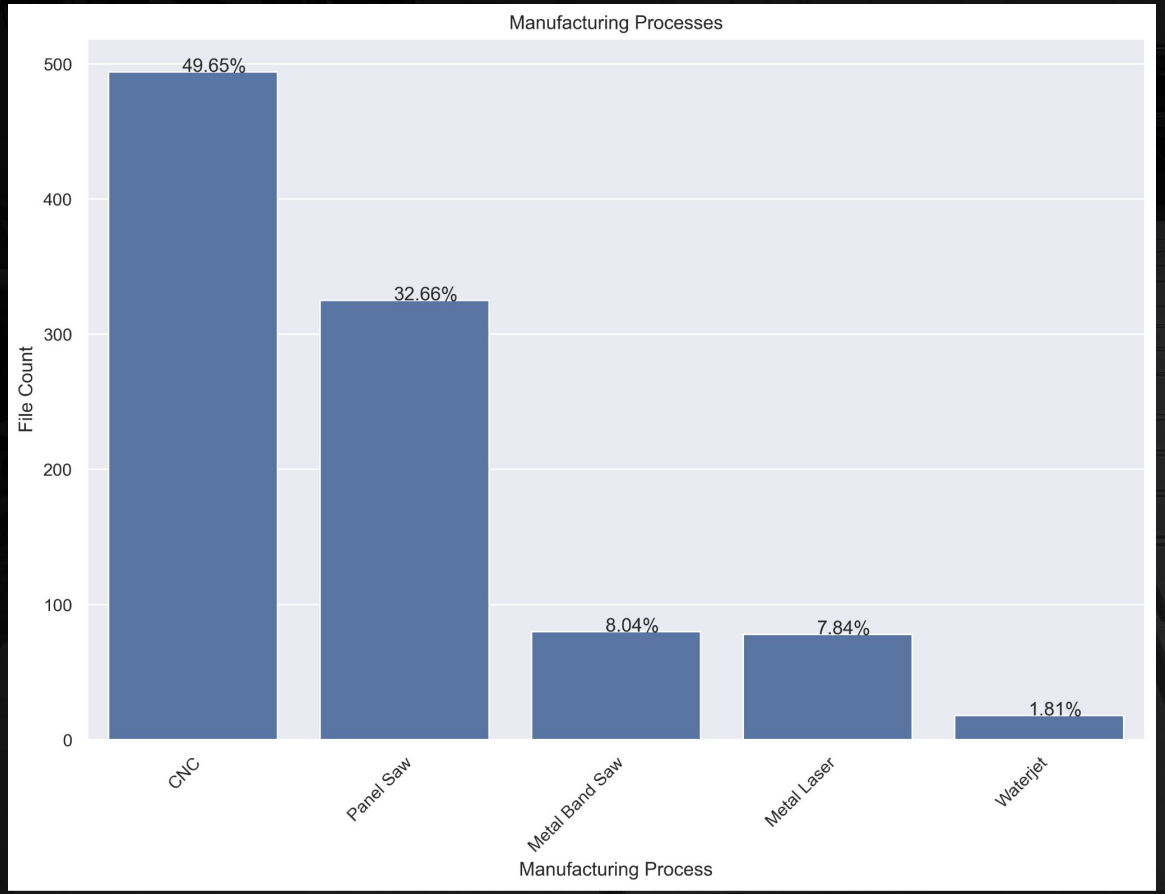
Table1
2 parts
28 configurations

Data Collection

- Meshes show a variety of shapes from different parts
- Human identified class of cutting manufacturing process



Data

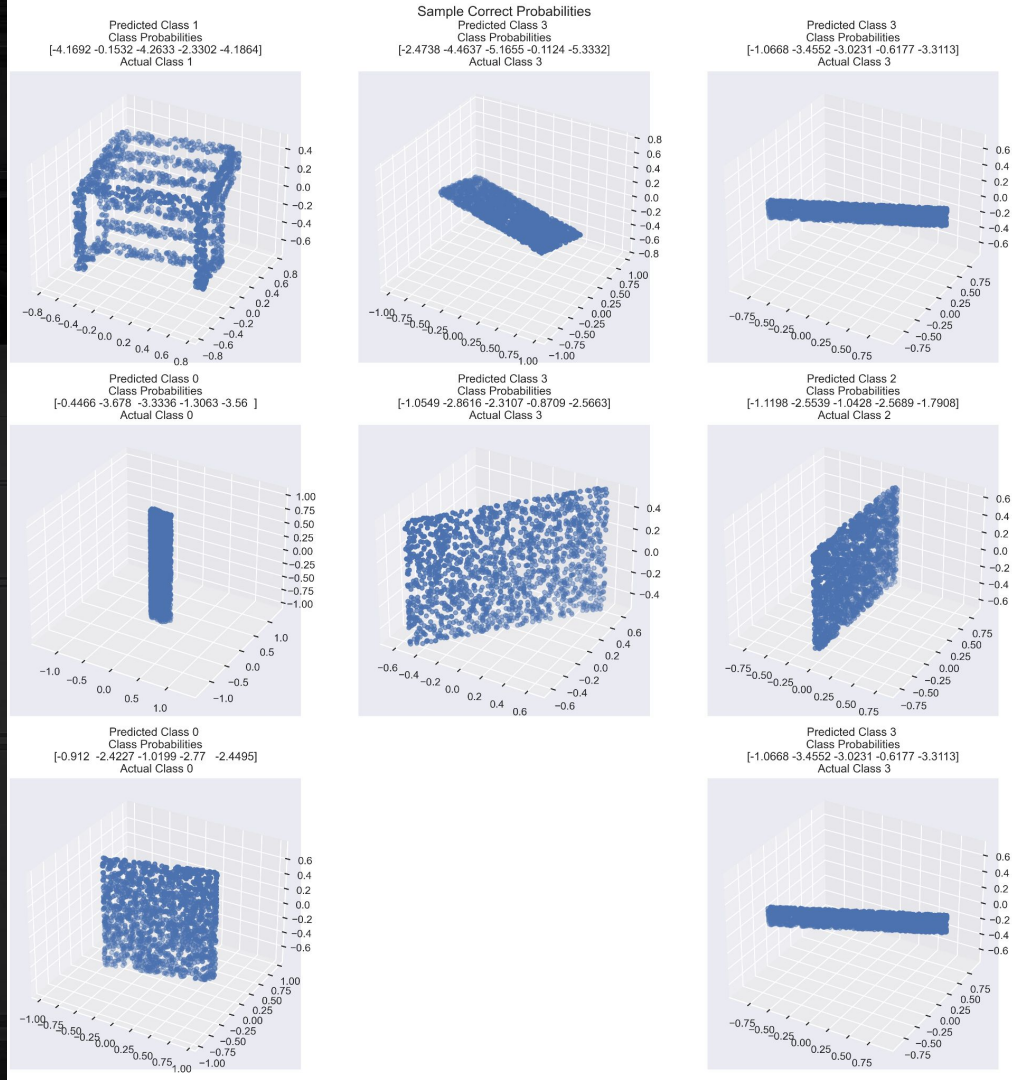


- 995 parts model in total, divided into 5 classes

- CNC and Panel Saw are the most common processes used at the machine to cut material

Data - Correct

Correct meshes show metal weldments and flat panels



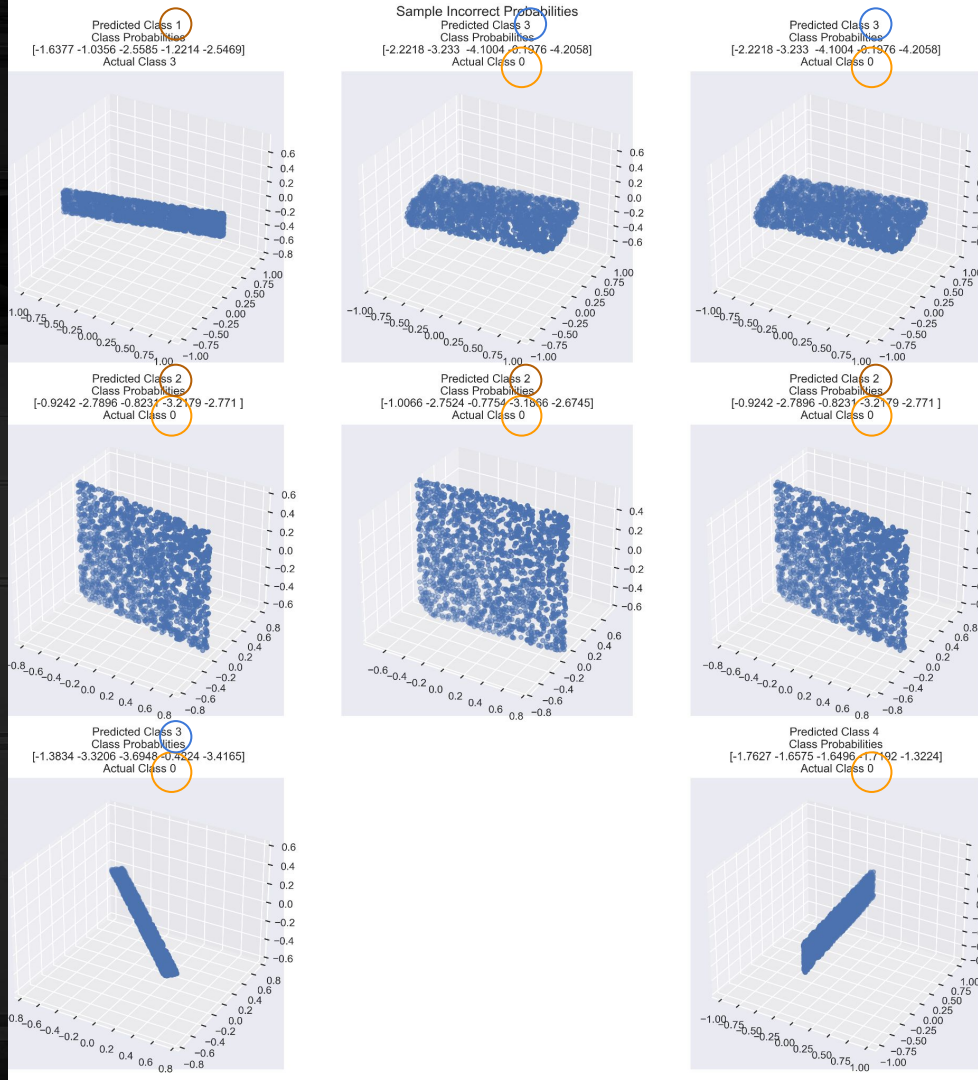
Data - Incorrect

Incorrect images show images which have varied issues to be dealt with:

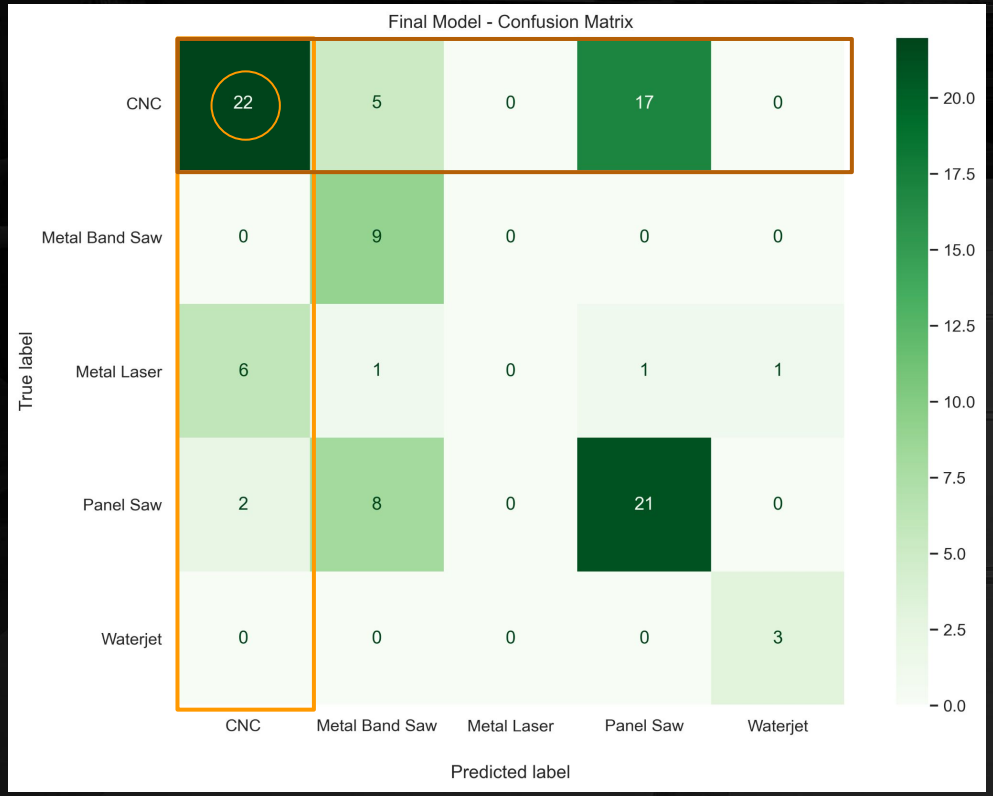
Most mispredictions in CNC (0) class

Material feature integrated into model would fix mispredictions with Metal Laser (2) and Metal Band Saw (1)

The Mesh faces integrated into a different model architecture would fix mispredictions with Panel Saw (3)



Results



Metrics

Total of 96 items in test set

CNC Precision at 73%

CNC recall at 50% and F1-score at 59%

Recommendations - Implementation

Model can be **implemented** for designating CNC processes with engineering supervision

Human assignment should happen for **all items identified as not CNC** by the algorithm.

Manual assignment to the **CNC class** needs to be **triple checked**

An **assignment flow diagram** should be given to an **administrative member to handle assignments**

Model shall be **improved over a 90 day period,** after which full deployment for all 5 classes would be possible.

Next Steps

1

Increase amount of **data** to train on by using 10,000 or 20,000 3D models

2

Gather more accurate measurements on machine time from the factory rather than provided estimates

3

Better accuracy could be obtained by **utilizing other types of neural network architectures** (not only analyzing pointclouds)

4

Integrate materials into the modeling

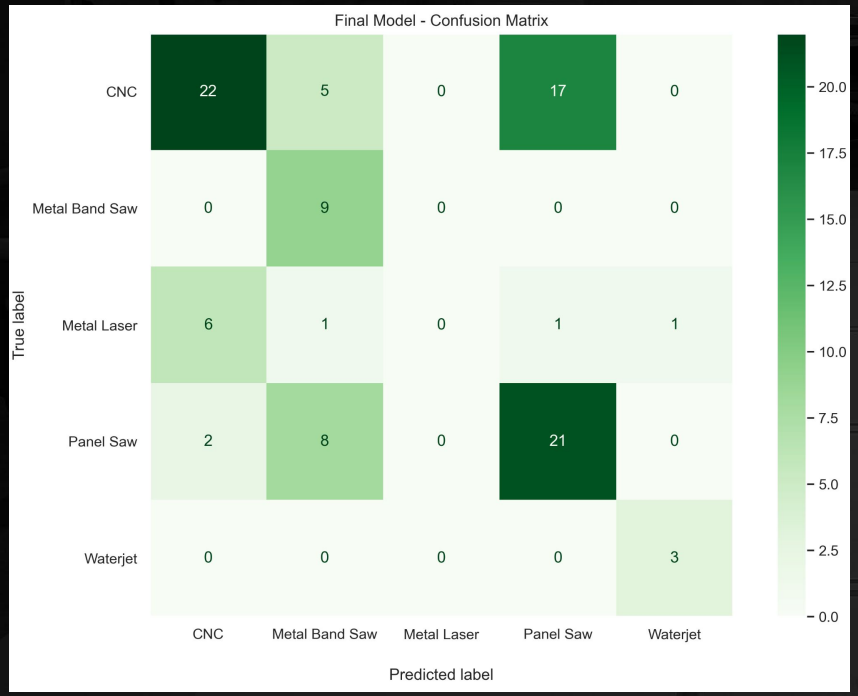
5

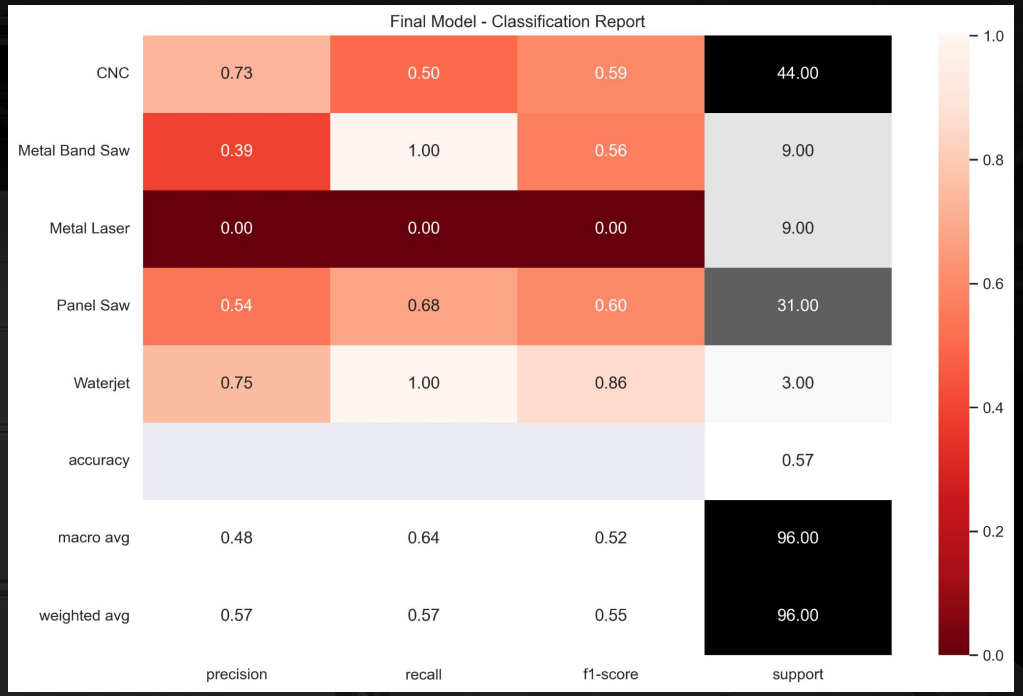
Gather more accurate measurements for material square footage from the models rather provided estimates


THANK YOU

APPENDIX

Data - Final Model

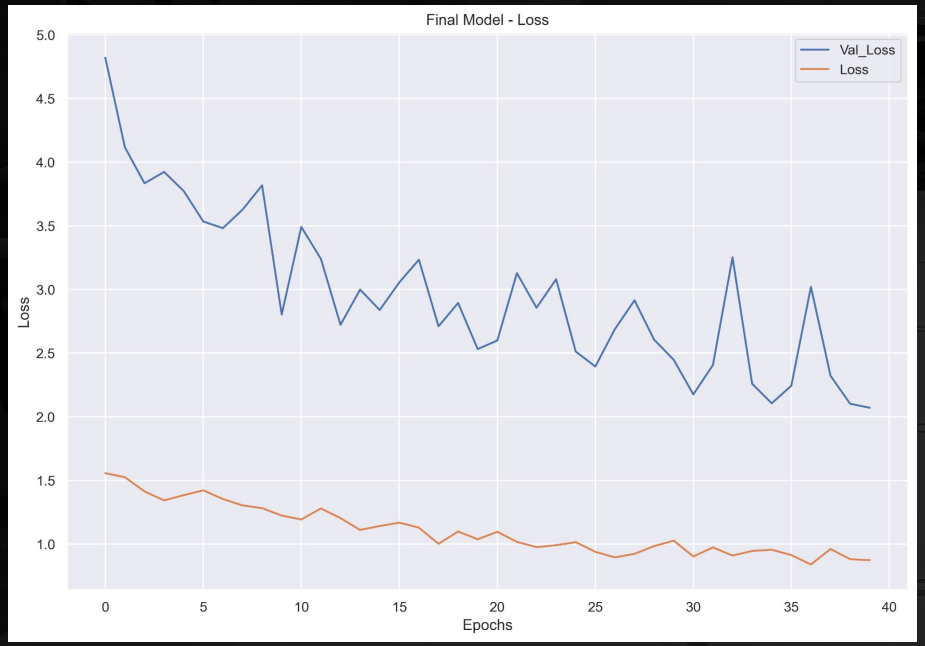




Precision for CNC is perfect

High values overall metrics
without data augmentation

Data - Final Model



Loss improving over time

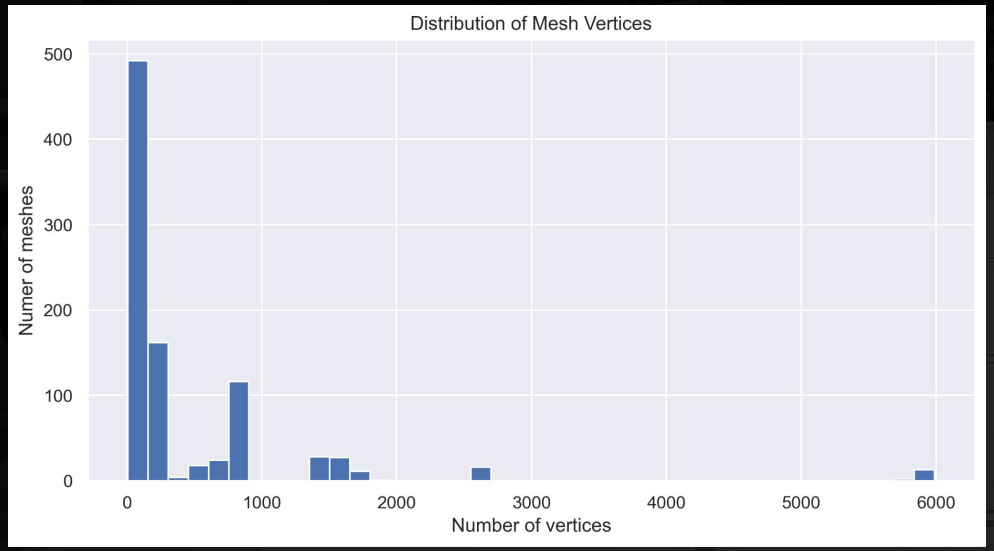
Accuracy improving over time

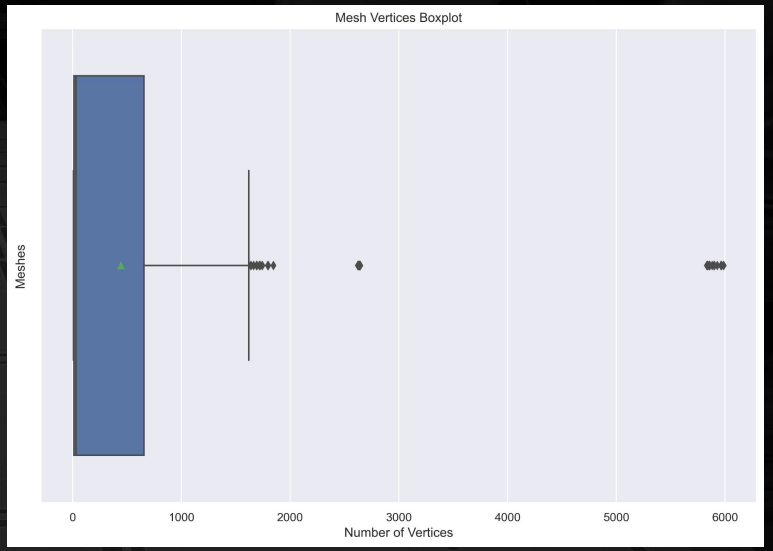
Data - Time Material Cost

CNC highest time cost

TFL highest spending
CNC highest material cost

Data - Mesh Vertices

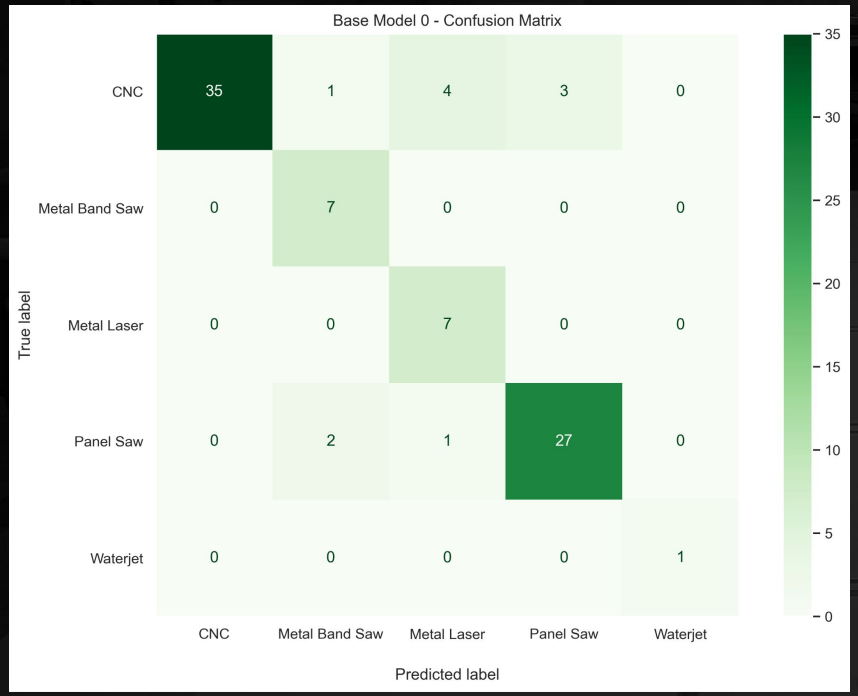




Wide variance in mesh vertices

Outliers at 6000 and 2600 vertices

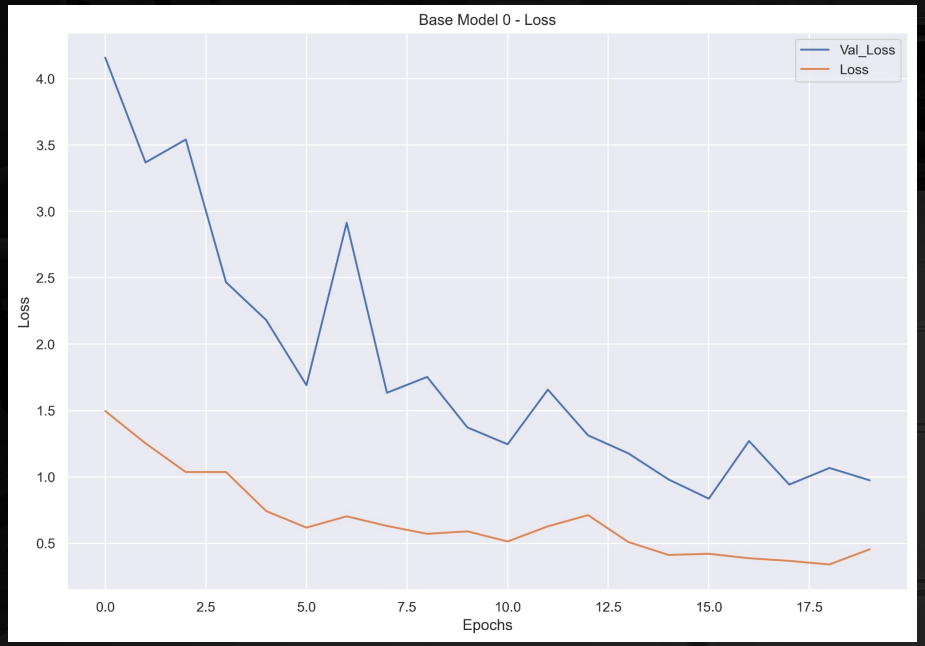
Data - Base Model

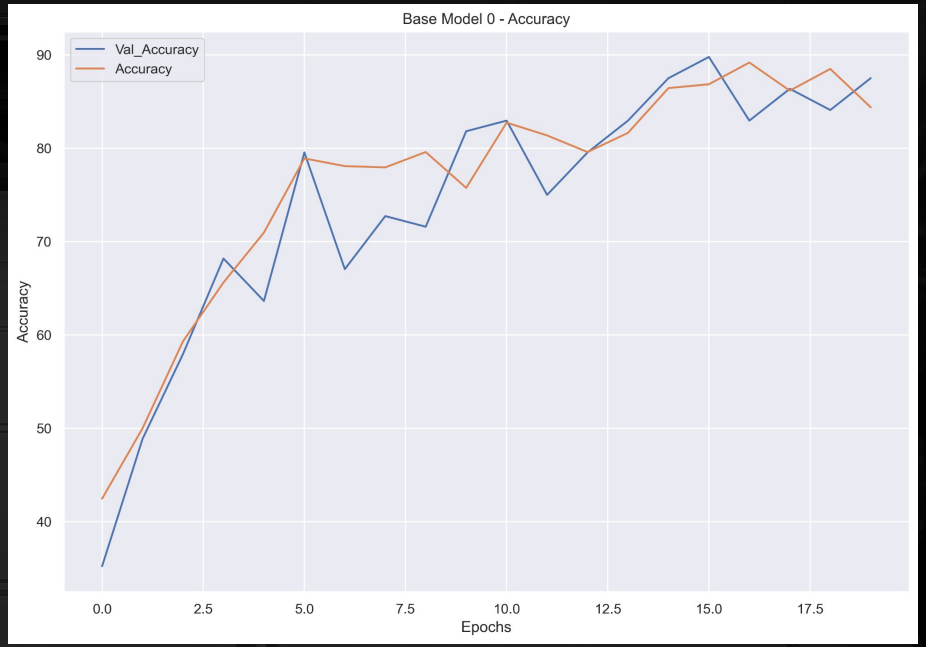


Precision for CNC is perfect

High values overall metrics
without data augmentation

Data - Base Model

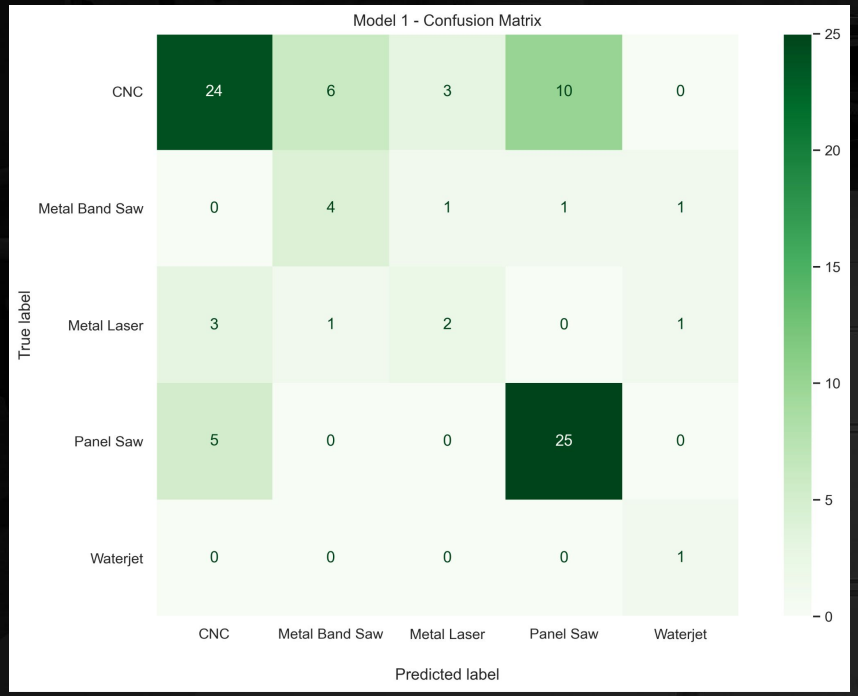


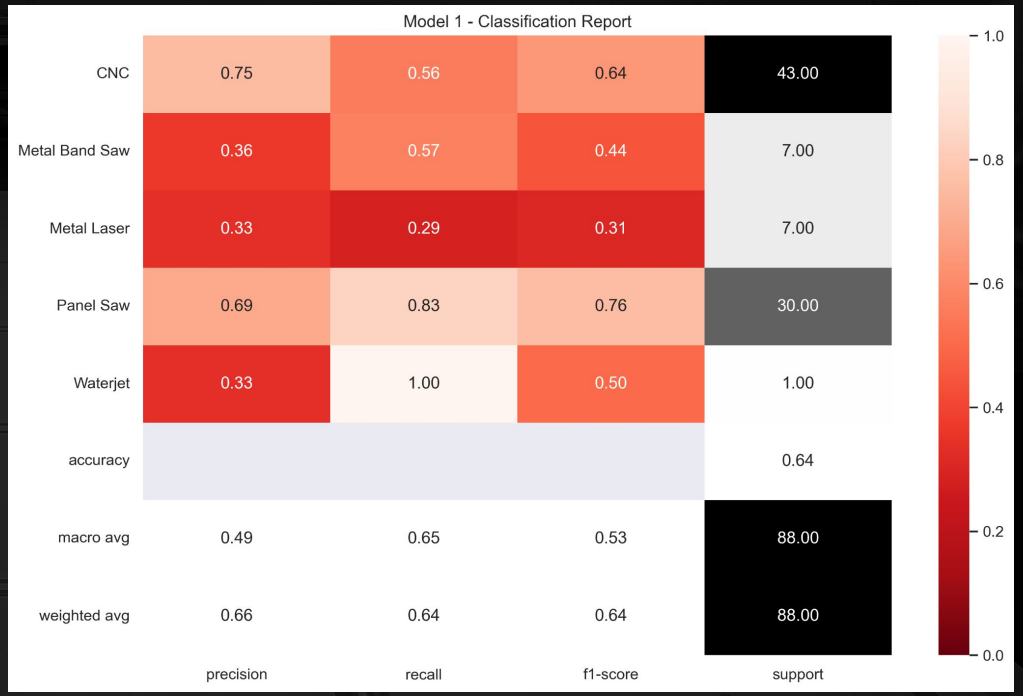


Loss improving over time

Accuracy improving over time

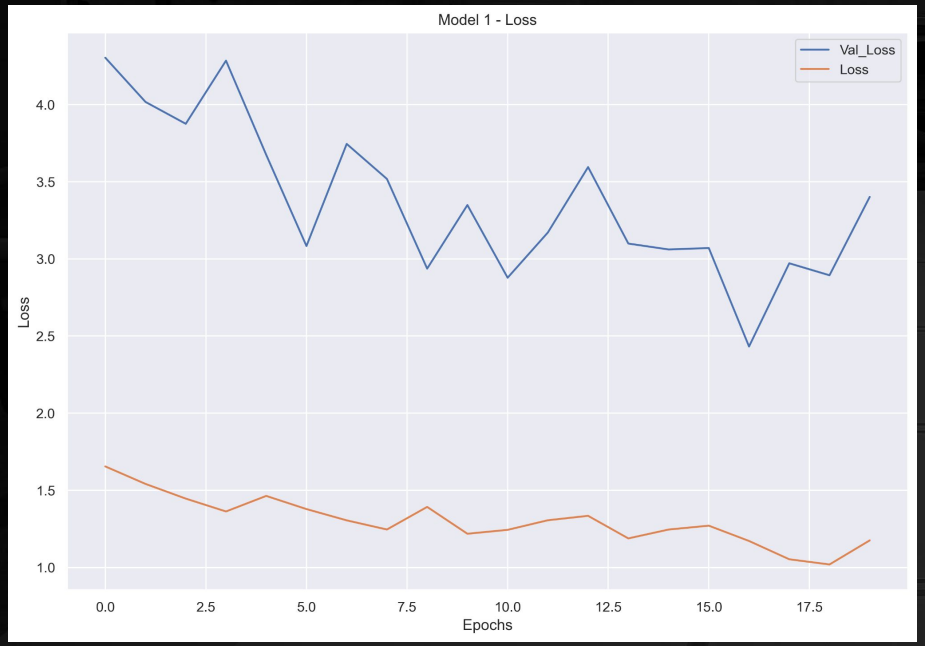
Data - Model 1

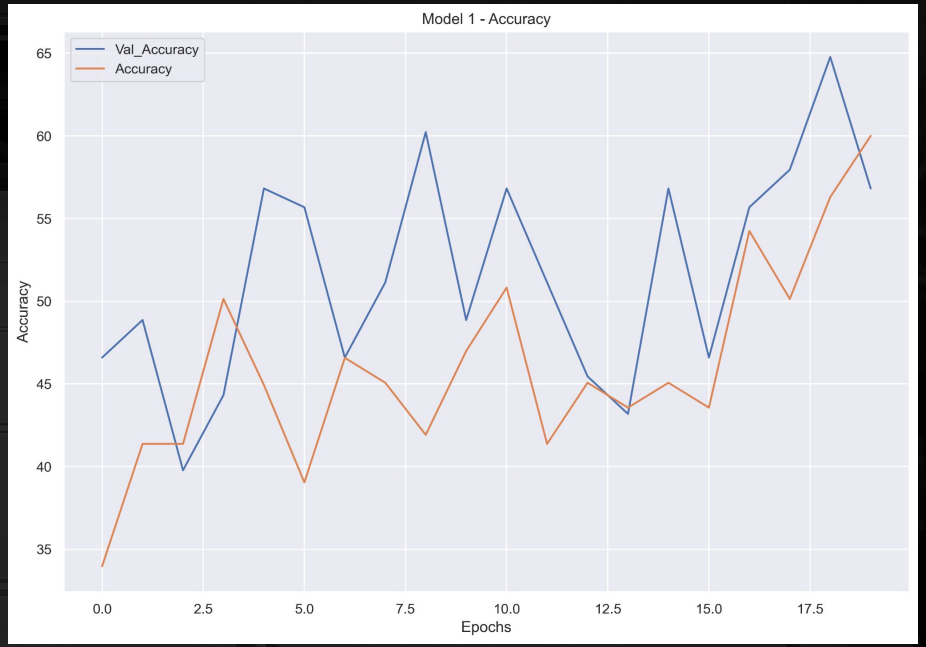




Values **with data augmentation**

Data - Model 1

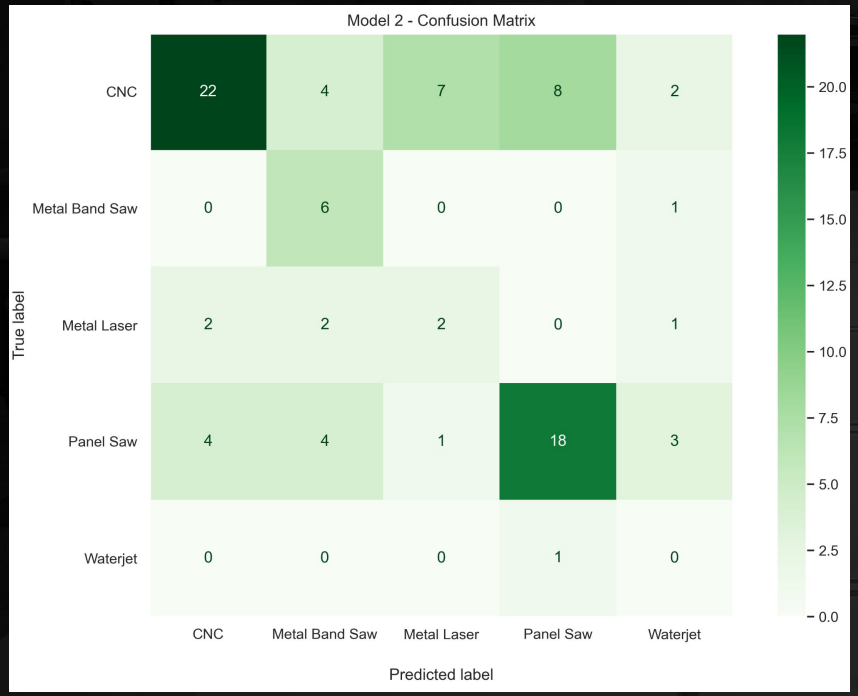


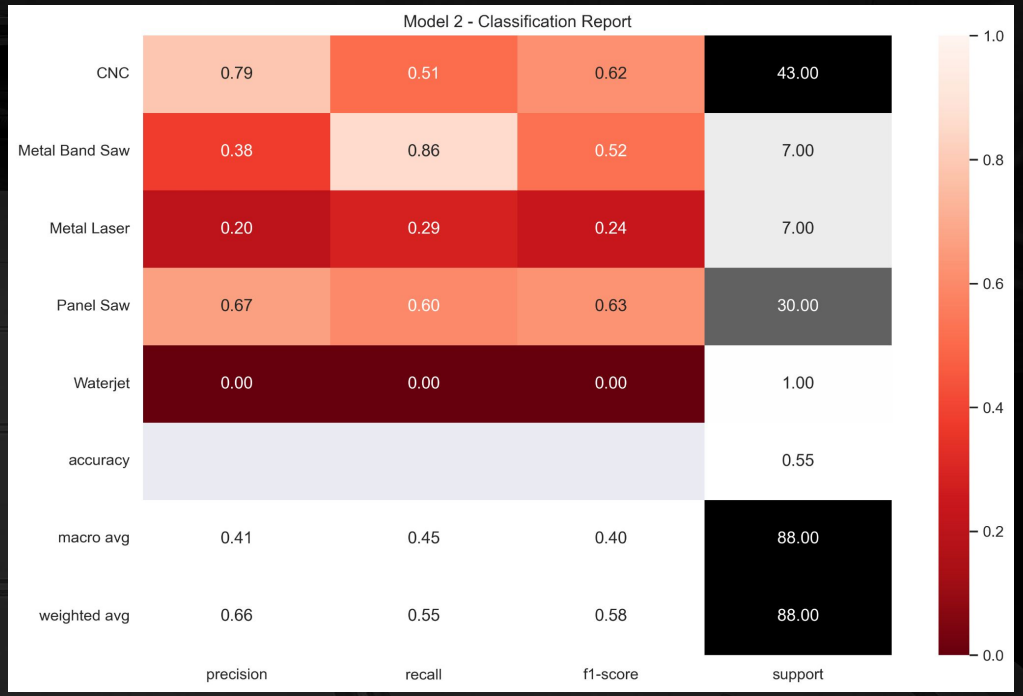


Loss improving over time

Accuracy improving over time

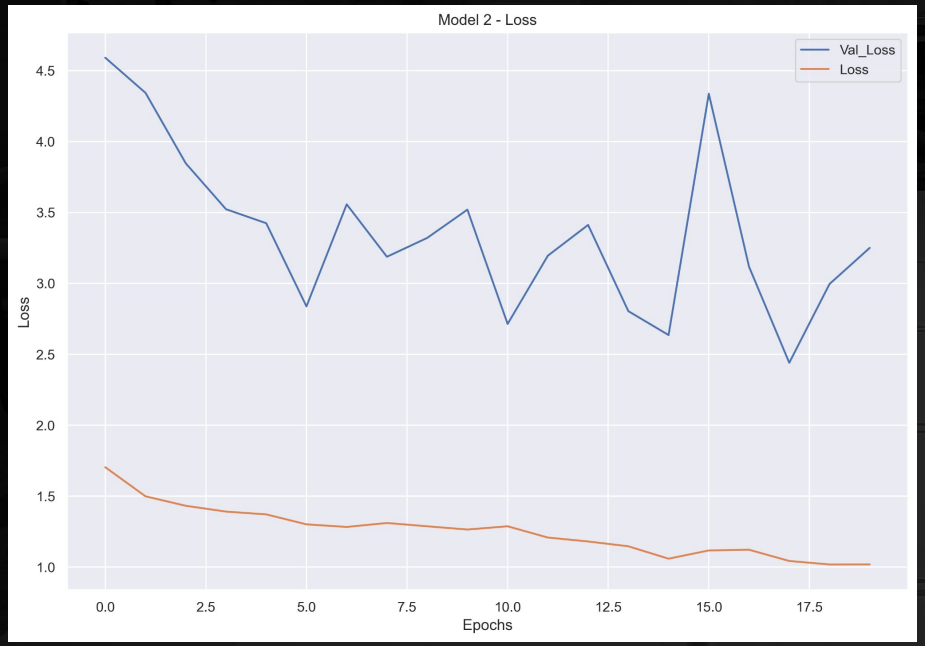
Data - Model 2





Values **with data augmentation**
Expand Channels for neural network

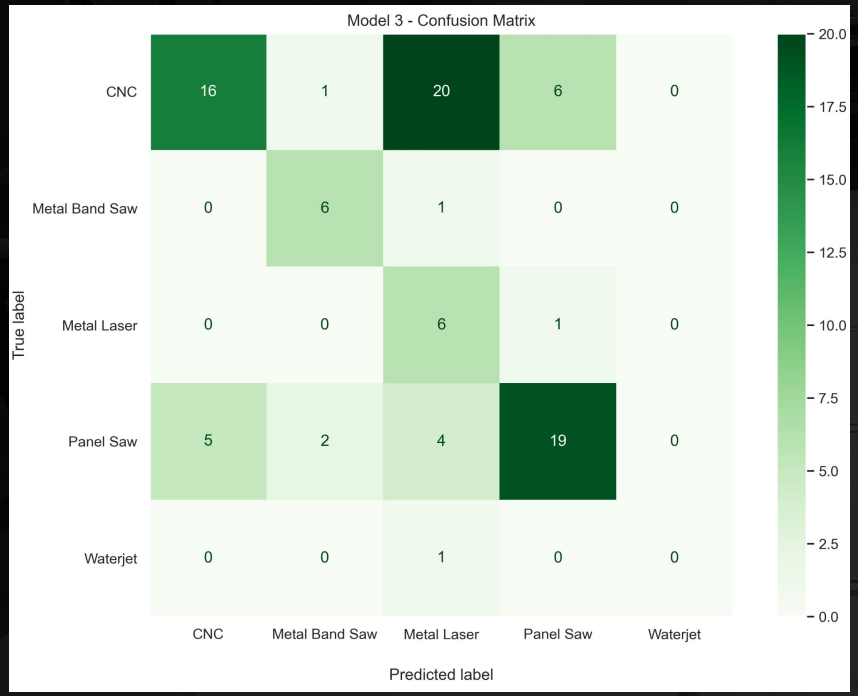
Data - Model 2

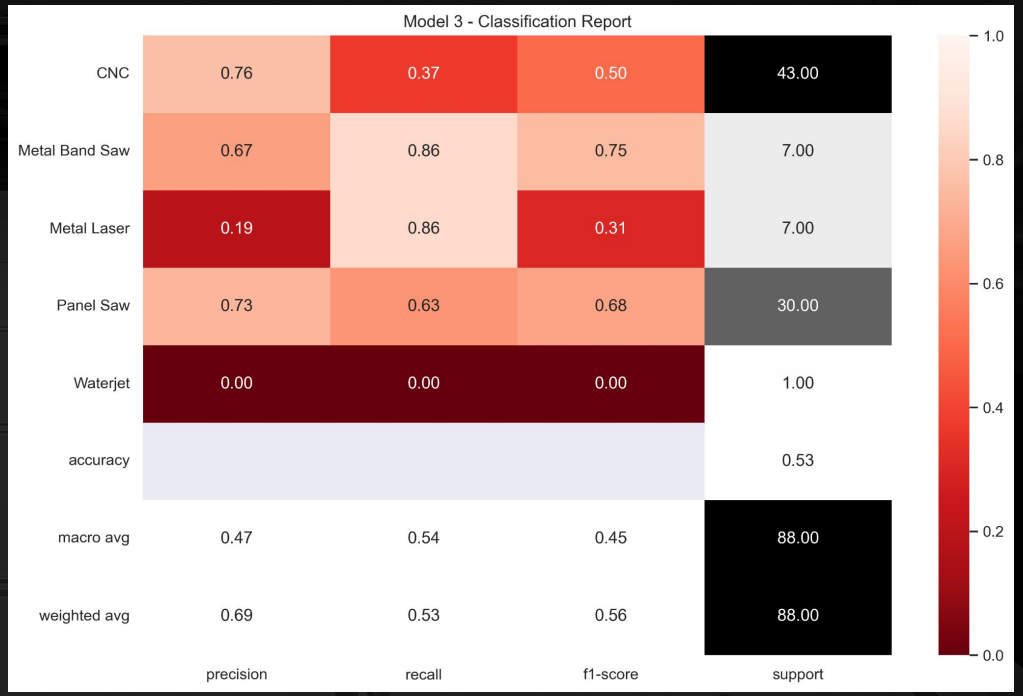


Loss slowly improving over time

Accuracy improving over time

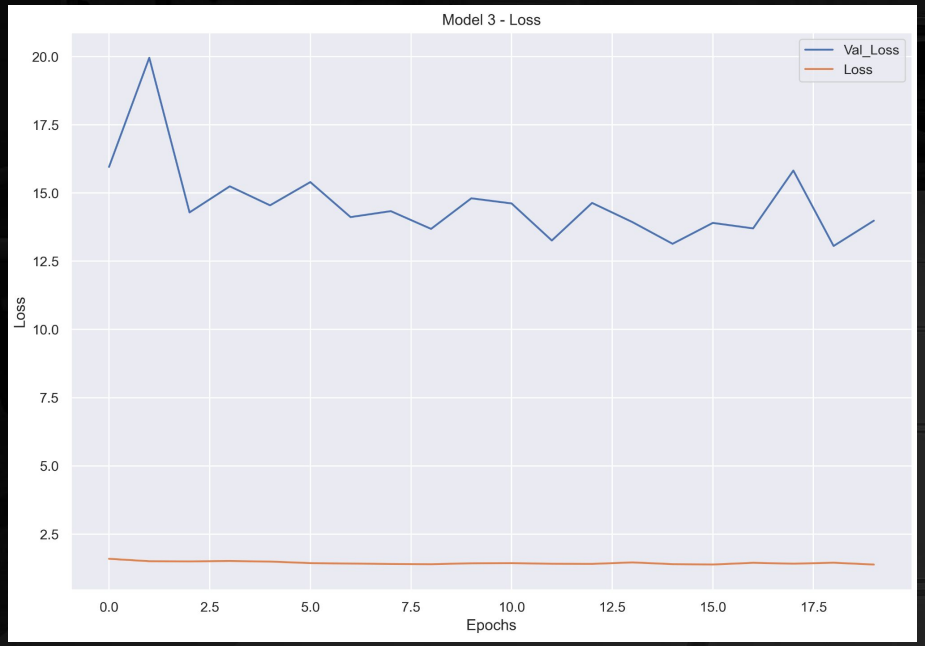
Data - Model 3

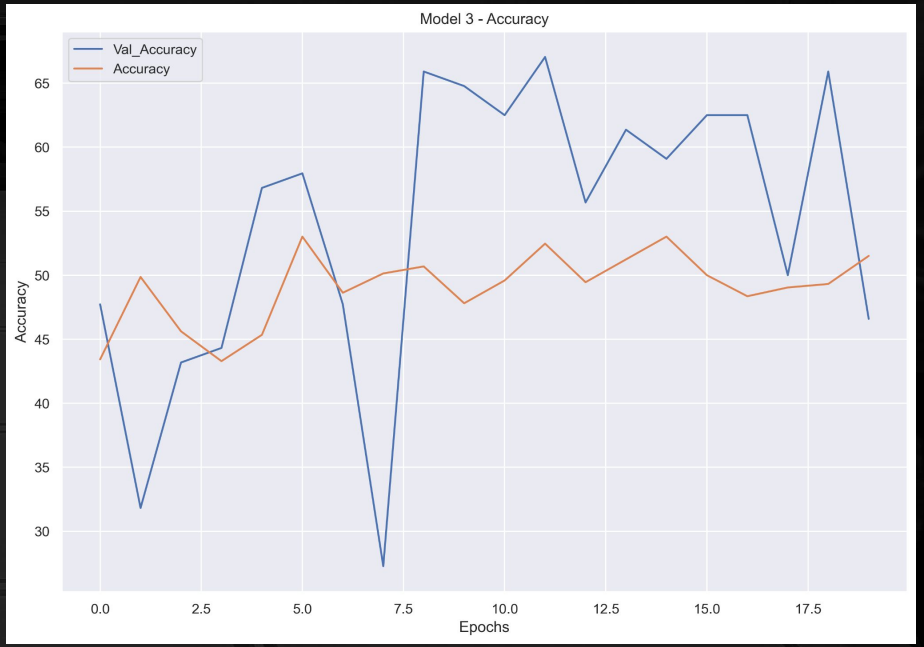




Values **with data augmentation**
Lower batch size and different optimizer

Data - Model 3

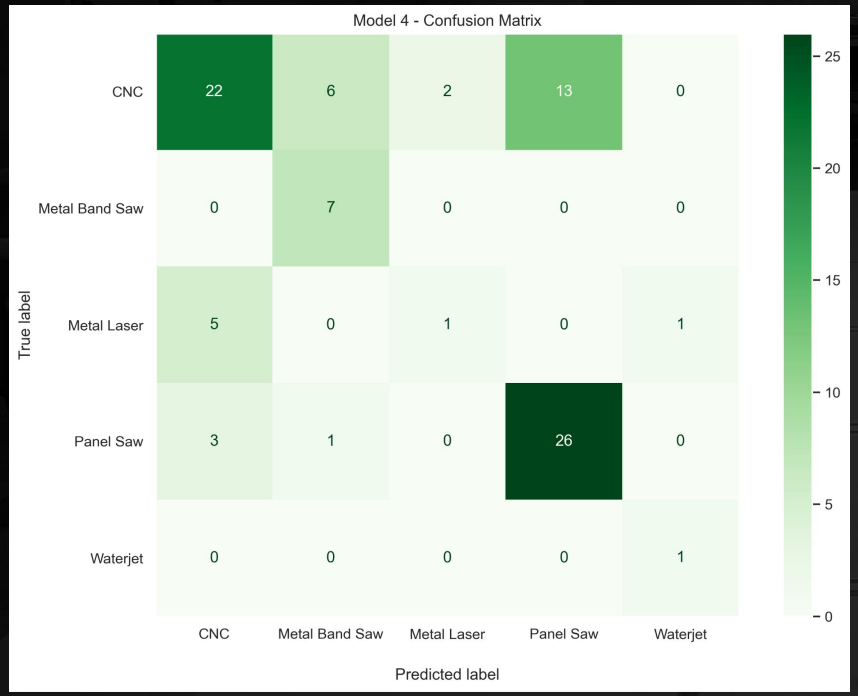


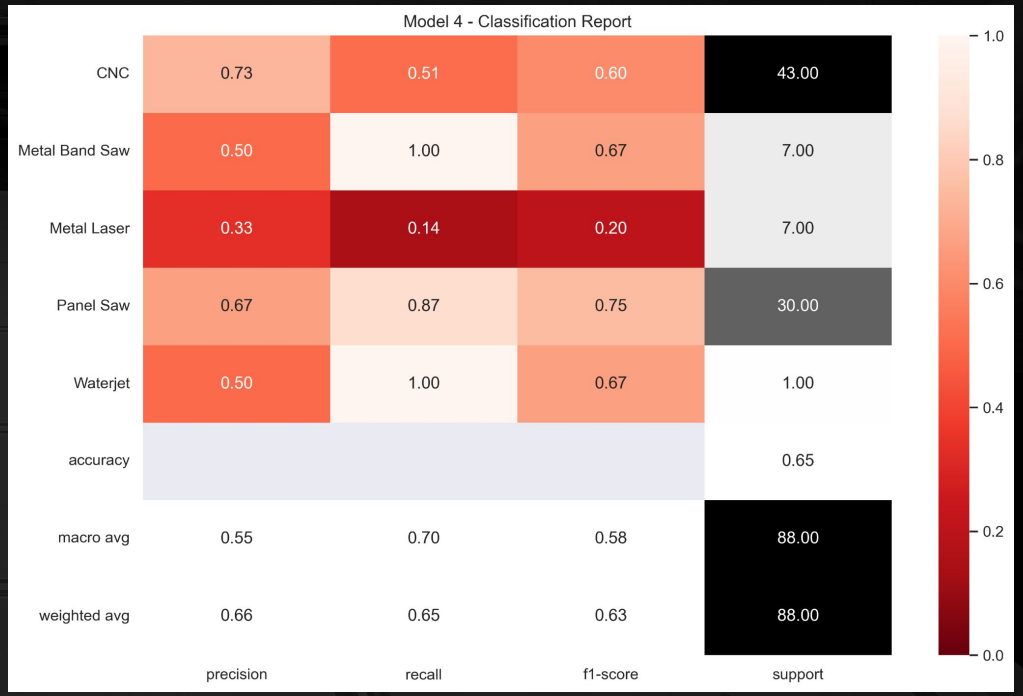


Loss stagnating

Accuracy erractic

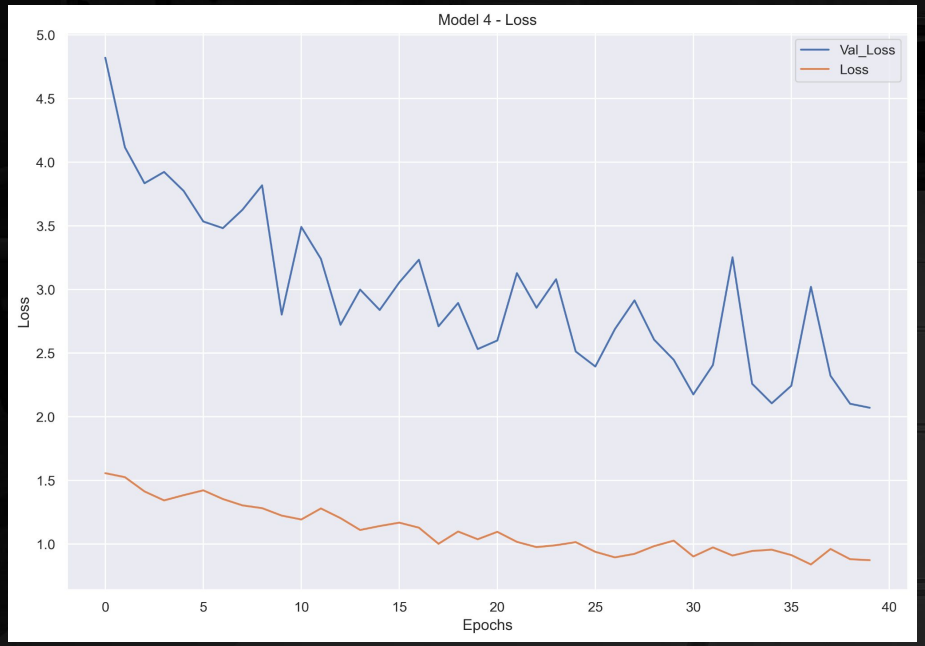
Data - Model 4





Values **with data augmentation**
Longer training improving on model 2

Data - Model 4



Loss improving over time

Accuracy improving over time